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Studies on Genera *Mallomonas*, *Synura* and Other Plankton in Freshwater with the Electron Microscope. (V) On the similarity of the fine structure between scale of *Mallomonas* and frustule of Diatom.*

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The suggestion on the similarity of the fine structure between the scale of *Mallomonas* and the frustule of diatom was given by Dr. Taira KAMIYA at the Congress of the Botanical Society of Japan in 1963. The present writer explains a brief consideration on this interested subject.

The writer wishes to express his thanks to Dr. Taira KAMIYA of Aichi Gakugei University for his valuable advice and kindness, and also to Professor Noboru ABE for his constant guidance.

The fine structure of scales of *Mallomonas* observed with the electron microscope by the writer is explained as follows. The scale of *Mallomonas fastigata* has a perforated shield, which shows the same structure both on the inner and outer sides (Pl. Ⅰ, fig. 1). The scale of *Mallomonas regina* has the perforated inner plate, whose pores arrange in longitudinal rows, and the mesh pattern is seen on the outside (Pl. Ⅰ. fig. 2, Pl. Ⅱ. figs. 5, 8), and the inner plate of *Mallomonas crassisquama* and *Mallomonas eoa* is perforated evenly (Pl. Ⅰ, figs. 3, 4. Takahashi 1961, 1963). The both sides of the scale of the two species show the different structure respectively, and it seems that these scales are made up of two layers, namely, the perforated inner layer which is in contact with the protoplasm, and the reticulate layer which opens towards the outside. And the ridge of the reticulate structure runs on the area generally between the pores as is shown in figure 3 in plate Ⅰ.

These structures are shown in figure 1. (see P. 138)

But in *Mallomonas regina*, it seems that a thin membrane develops along the ridge as is shown in figure 8 in plate Ⅱ, and this membrane is similar to the cover membrane of the loculus in the centric diatom.

Since the studies on *Mallomonas* with the electron microcope were published by Fott (1955) and Asmund (1955), many studies on them have been done by many authors.

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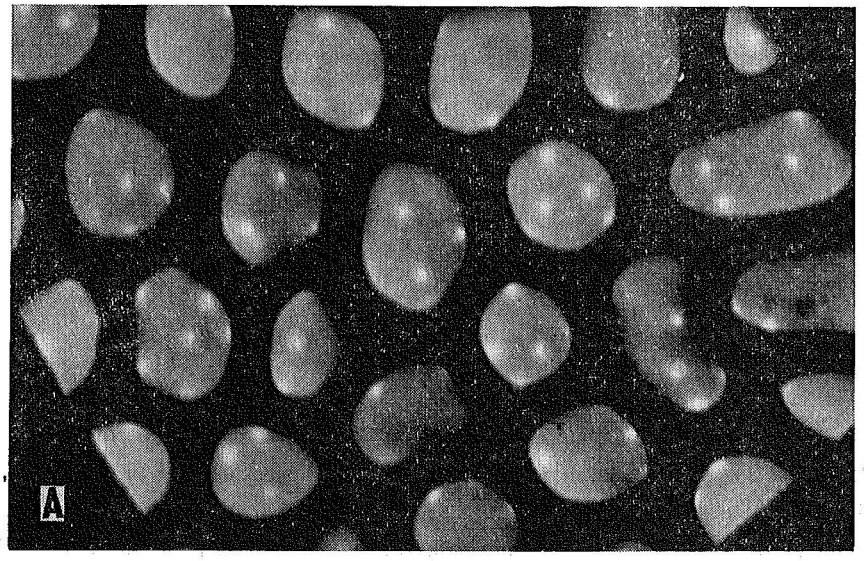
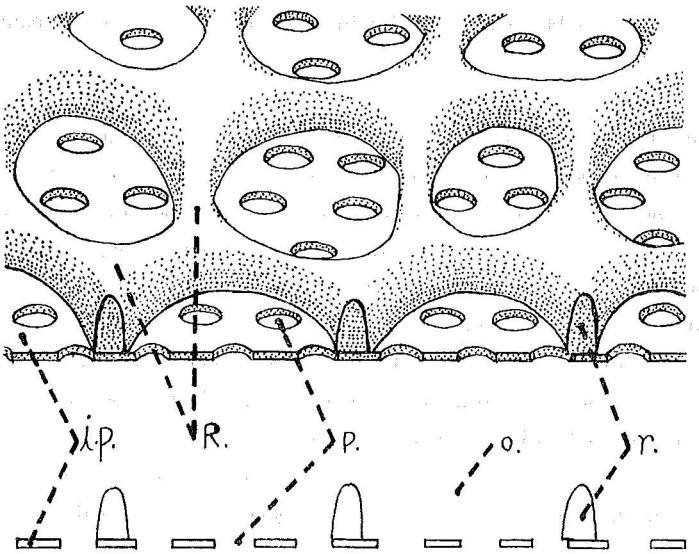
Figure 1. Fine structur of scale of *Mallomonas crassisquama*
A... Direct electron micrograph. X 45,000





i.p.…inner plate
o …outer opning
p …pore
R…reticutation (outer plate)
r …ridge

Harris and Bradley have revealed precisely the fine structure of the scale of a number of *Mallomonas* species, using the carbon replica technique, and they (1960) expressed that the mature scales of *Mallomonas allorgei* are made up of three layers : a perforated basal layer, a honeycomb layer, and a smooth roof which only develops in the mature scale.

The present writer studied on two species of the torquata group (Takahashi, 1963). One of them, *Mallomonas grata* seems to be intermediate between the torquatae and the quadratae according to the electron microscopic structure of the scale.

Conrad (1933) had classified at first the species of *Mallomonas*, and Bourrelly (1957) modified Conrad's grouping, based on the characters as seen in the optical microscope. Harris and Bradley (1960) arranged a number of *Mallomonas* species known with the electron microscope in a new scheme of classification.

But there is a hiatus between some isolated species and other groups. Further researches on that point are needed.

Bacillariophyceae is grouped among the Chrysophyta. Many workers have revealed the fine structure of the frustule, and Okuno (1949) published on the general structure of the loculus of the centric diatom, and in 1953, he classified diatom frustules on the basis of the sieve membrane structure of the areolae and distinguished 23 types, and also Desikachary (1956) and Hendey (1959) classified them in another way.

According to the present writer's observations on *Mallomonas* and a few diatoms, and to many studies on the diatom given by many authors, he recognized the similarity of the structure between the scale and the frustule.

The frustule of *Melosira* is formed of the perforated sieve membrane and the netveined structure (Okuno, 1954. Helmeck and Krieger 1960), (Pl. Ⅱ, fig. 7). It seems that Figure 1 in the present paper can be considered as a figure of the general structure of the frustule of *Melosira*, by changing the inner plate and the minute pore of *Mallomonas* in the figure 1 respectively, for the sieve membrane and the single sieve pore of the diatom. And the structure of the scale of *Mallomonas regina* which develops the fine membrane along the ridge (Pl. Ⅱ, fig. 8), shows clearly its similarity to the structure of the loculus of the centric diatom with the cover membrane.

In the centric diatom which shows the similar structure to the scale of *Mallomonas*, the loculus opens on the inside and so the sieve membrane is on the outside generally. That relative position of the two is opposite to that of the reticulate layer and the perforated layer of *Mallomonas*, but it seems that the structure of the scale and that of the frustule is fundamentally identical.

Chrysophyceae, Xanthophyceae and Bacillariophyceae are united to the same phylum under the name of Chrysophyta, or Bivalvophyta proposed by Hirose (1959). The common characters which permit to unite them are as follows ; 1) identic pigment, 2) same reserves, 3) cyst of same origin, of same form, and same nature, 4) membrane with similar structure, 5) flagellum with similar fine structure, etc. (Bourrelley, 1957), and the diatom had branched from the trunk of Chrysophyceae (Fott, 1957), and it can be decided that they have a common ancester (Bourrelley 1957).

And also Parke (1959) suggested that in Chrysophyta, there is one series with affinities towards the diatom, the other series related closely to some coccolithophorid form (cited by Desikachary, 1959). The present writer thinks that *Mallomonas* is placed

in the former series.

The comparison of the electron microscopic structure between the scale of *Mallomonas* and the frustule of the diatom has not yet been done sufficiently.

It seems that the morphological similarity between the two is one of characteristics which give evidence to the relationship between Chrysophyceae and Bacillariophyceae.

Summary

The fine structure of scales of *Mallomonas* : *Mallomonas fastigata*, *Mallomonas regina* and *Mallomonas crassisquama*, is explained, (of the last species especially with figures).

The present writer compared the fine structure of *Mallomonas* with the structure of the frustule of *Melosira granurata* and the other centric diatom, and explained a similarity between them.

It seems that the morphological similarity between the scale of *Mallomonas* and the frustul of the diatom is one of characteristics which permit to unite Chrysophyceae and Bacillariophyceae.

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摘　　要

Mallomonas, *Synura* 属及び他の淡水産プランクトンの
電子顕微鏡による研究. Ⅴ.
Mallomonas の鱗片と珪藻殻の微細構造の類似について

高　橋　永　治

電子顕微鏡による観察から，*Mallomonas* の鱗片の構造は次のように言うことができる．

Mallomonas fastigata は内外面同一の構造を示す (Pl. Ⅰ, Fig. 1). *Mallomonas regina*, *Mallomonas crassisquama* や *Mallomonas eoa* は，内面は孔のある平板で，外面に網状構造が発達し，内外面は異なつた構造を示す (Pl. Ⅰ, Figs. 2, 3, 4, Pl. Ⅱ, Fig. 5). これは内外膜2層からできていると言える．この構造は Fig. 1 に示される．

Mallomonas regina では，網状構造の上に小さい膜が発達していると思われる (Pl. Ⅱ. Fig. 8・M). この膜は，中心型珪藻の殻の蓋膜と類似している．

HARRIS と BRADLEY (1960) は，*Mallomonas allorgei* の鱗片は3層の膜からできていることを報告し，同時に電子顕微鏡で観察された種を4群と孤立種の群とに分類した．

著者は1963年に *Mallomonas grata* を発表したが，この種は鱗片の構造から，*Quadrata* 群と *Torquata* 群の中間の特徴をもち，両群を結びつける種であると考えられる．しかし HARRIS と BRADLEY の分類の中の孤立種の群と他のものとのつながりは明らかでなく，また*Mallomonas* と他の属とのつながりの間にも，隙間があるなど，系統上多くの問題が残されている．この点については，次の機会にゆずることにする．

珪藻殻の微細構造は，奥野氏らによつて明らかにされている．*Mallomonas* の鱗片の構造と，珪藻殻の構造を比較すると，両者はよく似ていることがわかつた．とくに *Melosira* や他の中心型珪藻の殻の構造と類似しており，Fig. 1 は，各部の名称を取り換えれば，*Melosira* の殻の構造として示しうると思われる．

黄色鞭毛藻類と珪藻類は黄緑色藻類と共に同一の門にまとめられている．今まで，電子顕微鏡で観察された鱗片と珪藻殻との構造上の類似については，あまり述べられていない．これらの形態上の類似は，両者を結びつける特徴であると思われる．すなわち，両者が近縁であることを証拠だてる特徴の一つとして考えられるものである．

Explanation of plates (all figures are original)

Plate Ⅰ

Fig. 1. Outer side of scale of *Mallomonas fastigata* (replica). × 10,000

Fig. 2. Outer side of scale of *Mallomonas regina* (shadowed) × 15,000

Fig. 3. Inner side of scale of *Mallomonas crassisquama*. (outer reticulation is seen as white net work) × 22,000

Fig. 4. Replica of outer side of scale of *Mallomonas crassisquama*. × 34,000

Plate Ⅱ

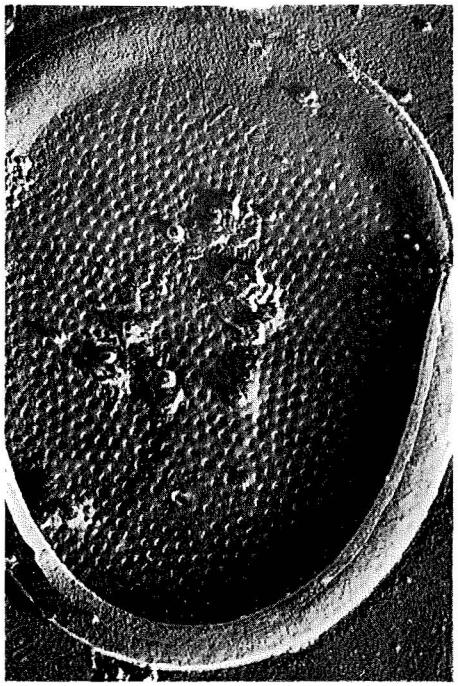
Fig. 5. Direct electron micrograph of scale with well-developed reticular structure of *Mallomonas regina*. × 14,000

Fig. 6. Direct electron micrograph of frustule of a centric diatom. × 20,000

Fig. 7. Direct electron micrograph of *Melosira* (cf. *M. granulata*) a… × 13,000, b… × 2,700

Fig. 8. A part of scale of *Mallomonas regina*. × 70,000
R…ridge, M…membrane developed along the ridge.

Plate I



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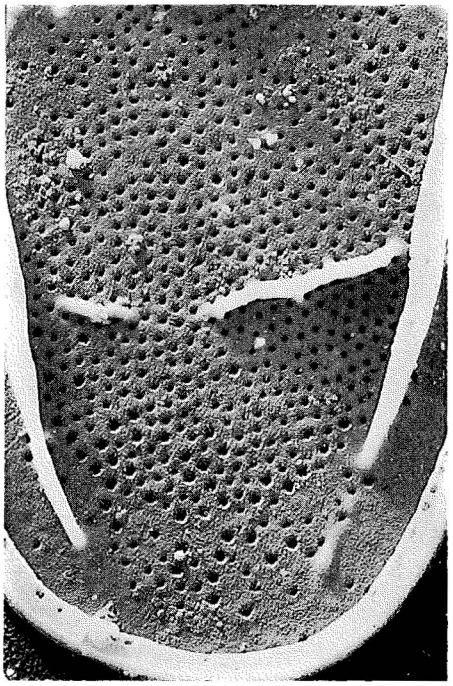

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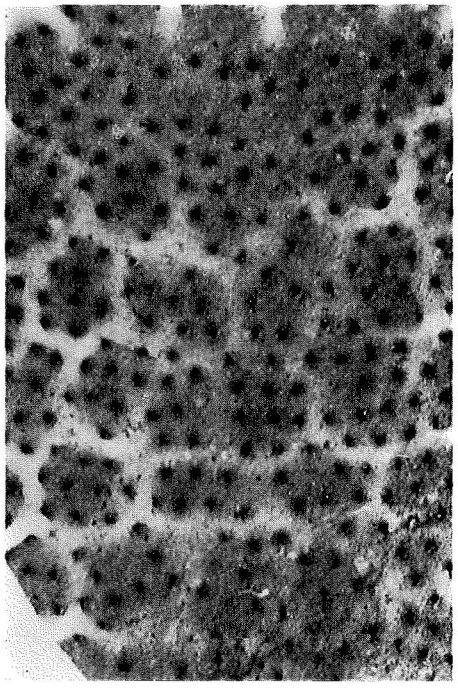

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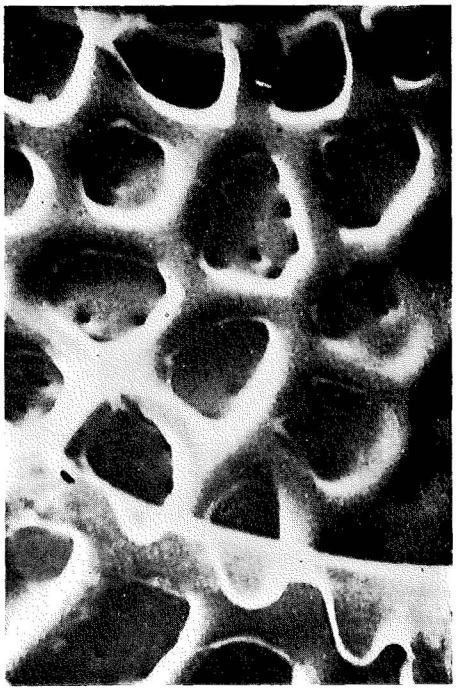

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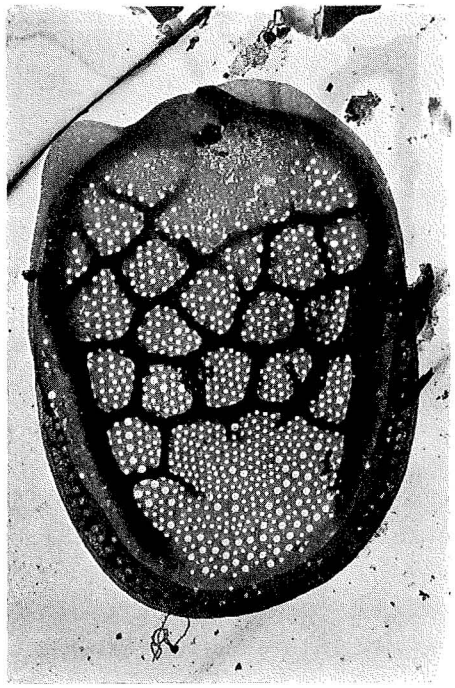
Plate Ⅱ



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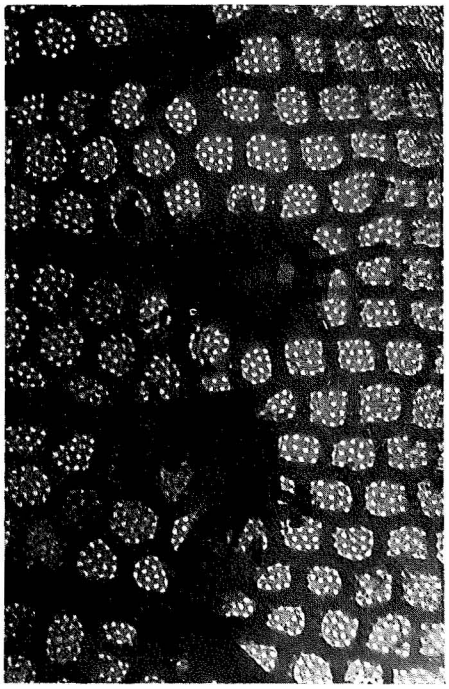

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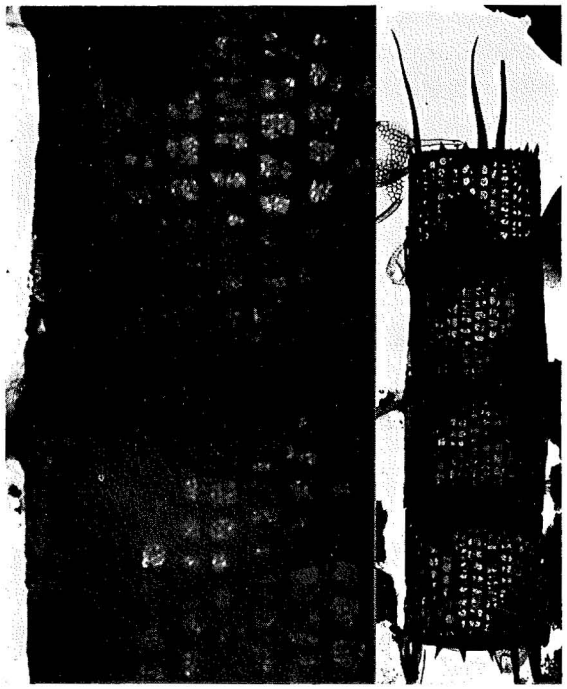
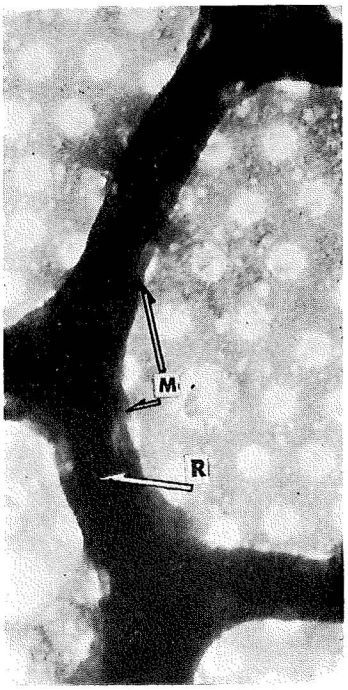


7 a

7 b



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